

# RAW MATERIALS

UDC 666.32:666.3.015.3/.4

## CLAY FROM SEMIKARAKORSKOE DEPOSIT

N. S. Rusovich-Yugai<sup>1</sup>

Translated from Steklo i Keramika, No. 11, pp. 21–22, November, 2005.

Clay from the Semikarakorskoe deposit (Rostov Region) is analyzed for its applicability in the production of ceramics. This clay is a low-melting, poorly sintering polymimetallic clay containing impurities in the form of organic inclusions, calcite, feldspar, and quartz. It can be used in the production of construction ceramics and majolica.

The prospected clays from deposits in the Rostov Region (Vladimirskoe, Gukovskoe, Chumakovskoe, Kiselevskoe, and Fedorovskoe) are used in the production of construction ceramics. Another clay deposit located near the town of Semikarakorsk has not been investigated before.

With the aim of determining the applicability of Semikarakorskoe clay for ceramic production, it was studied according to standard methods [1–3].

The determination of the degree of dispersion based on coarse-grain inclusions established that Semikarakorskoe clay belongs to the group of argillaceous material with a medium content of inclusions.

### Content of coarse-grained inclusions

Grain size, mm	Content of fraction, %
Over 7	2.3
From 7 to 5	8.8
From 5 to 3	23.9
From 3 to 1	34.6
From 1 to 0.5	11.7
From 0.5 to 0.25	4.1
Below 0.25	14.5

Based on its plasticity, this clay belongs to the low-plasticity group (plasticity number 1.47). Plasticity was determined using Zemyatchenskii's method. According to Nosova's method, the drying sensitivity coefficient is equal to 3, i.e., the clay belongs to the group of argillaceous materials highly sensitive to drying.

The thermal study indicates that as the firing temperature grows from 800 to 1000°C, the porosity of samples of the

considered clay decreases from 27.8 to 22.2%, and the water absorption drops from 15.2 to 3.3% (Fig. 1); the considered clay belongs to the poorly sintering group.

The mechanical strength of clay grows as the firing temperature grows to 950°C, but a rise in temperature to 1000°C leads to an insignificant decrease in strength, and then upon a rise in temperature to 1050°C the strength again slightly grows (Fig. 2). The mechanical strength in the air-dry state is 5 MPa. Thus, the maximum strength of the clay considered is equal to 26.4 MPa and can be provided within a temperature interval of 900–950°C.

Shrinkage was measured in the interval of 850–1050°C. It was found that fire shrinkage varies insignificantly and lies

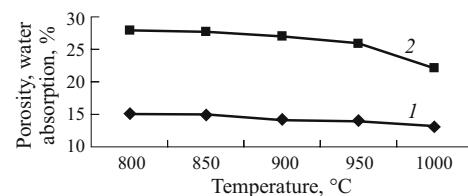


Fig. 1. Dependence of water absorption (1) and porosity (2) on firing temperature.

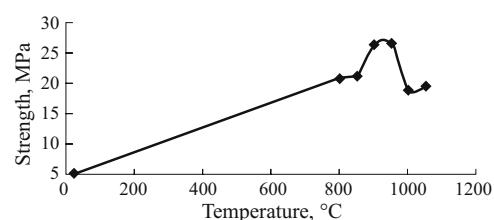


Fig. 2. Mechanical strength of clay from Semikarakorskoe deposit.

<sup>1</sup> Gzhel'skii State Art-Industrial Institute, Gus'-Khrustal'nyi, Vladimir Region, Russia.

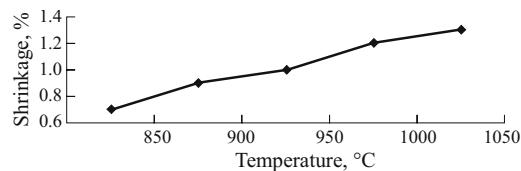


Fig. 3. Dependence of fire shrinkage on firing temperature.

within the range of 0.7 – 1.3% (Fig. 3), air shrinkage reaches 7.2%, and the total shrinkage is 8.3%.

The CLTE was determined using a dilatometer produced by the Bahr company. The rate of the temperature rise was 10 K/min. Samples of the clay considered fired at temperatures of 950 and 1000°C were shaped as bars with a square section (6 mm) of length 50 mm. It was found that the CLTE in the temperature interval of 20 – 400°C of clay fired at 1000°C is equal to  $8.11 \times 10^{-6} \text{ K}^{-1}$ , which is insignificantly higher than the CLTE of clay fired at 950°C, which is  $7.70 \times 10^{-6} \text{ K}^{-1}$ . Furthermore, the CLTE within the heating interval from 603 to 622°C grows in both samples ( $9.85 \times 10^{-6}$  and  $10.26 \times 10^{-6} \text{ K}^{-1}$ ). This is due to the polymorphous transformation of quartz accompanied by its expanding volume.

The differential-thermal analysis indicates that the clay considered contains organic impurities, calcite, quartz, kaolinite, and hydromica; the removal of hygroscopic water occurs at a temperature of 105°C. Consequently, the clay from the Semikarakorskoe deposit can be classified as kaolinite-hydromica clay with a high content of calcite impurity.

Reactions in clays under heating	Thermal effect temperature, °C
Endothermic, loss of physically bound (hygroscopicity) water.	105
Exothermic effect of organic impurities burning out	460
Endothermic effect of removing constitution (physically bound) water from kaolinite	524
Endothermic effect of removing constitution water from hydromica	560
Endothermic effect of transformation of quartz	580
Intense endothermic effect of dissociation of calcite $\text{CaCO}_3$	813
Endothermic effect of destruction of the crystal lattice of hydromica	846
Exothermic effect of recrystallization of products of hydromica disintegration	897
Exothermic effect of formation of mullite seeds in kaolinite	991

The microscopic analysis of clay was performed on an Omnimet integrated automatic analyzer. For microstructural analysis we prepared polished sections of clay fired at temperatures of 950, 1000, and 1050°C.

The clay fired at 950°C has a significant content of residual quartz: 20.5%. Quartz grains have usually a rounded and less frequently a detrital shape, the grain length is about 20.5  $\mu\text{m}$ , and the maximum grain length reaches 100 – 170  $\mu\text{m}$ .

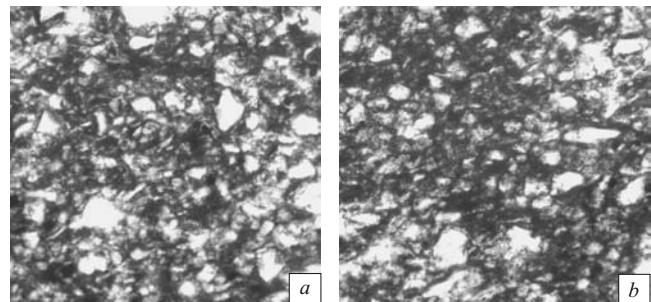


Fig. 4. Structure of clay from the Semikarakorskoe deposit ( $\times 142$ ) fired at temperatures of 950°C (a) and 1050°C (b).

The clay fired at 950 – 1050°C contains an insignificant quantity of weakly modified feldspar grains of size up to 50 – 60  $\mu\text{m}$ , as well as iron compounds in the form of dark-colored formations of size from 10 – 30 to 40 – 50  $\mu\text{m}$ , whose shape is nearly isometric or elongated (Fig. 4). Along with large irregular-shaped pores of length up to 100 – 140  $\mu\text{m}$ , there are fine pores of irregular shape of size ranging from 1 – 3 to 20  $\mu\text{m}$ . Some areas contain glass ceramic aggregates; sometimes inside these areas there are pores from 30 – 20 to 50  $\mu\text{m}$  or finer pores gathered in clusters.

The clay fired at 1000°C contains up to 18.3% residual quartz. Quartz grains have mainly a rounded shape, less frequently a detrital shape of size up to 20  $\mu\text{m}$ , and the maximum grain size is 100 – 150  $\mu\text{m}$ . The size of partly modified feldspar grains is 60 – 70  $\mu\text{m}$  and of iron compounds — 20 – 30 and 50 – 70  $\mu\text{m}$ . The pores are mainly of irregular elongated shape of length 100 – 120  $\mu\text{m}$ . Unlike the clay fired at 950°C, here one finds glass areas of size 20 – 30 and 100  $\mu\text{m}$ , occasionally with isometric pores inside those areas.

The clay fired at 1050°C has residual quartz grains of size 22 and 100 – 150  $\mu\text{m}$  in the amount of 18%, usually rounded, sometimes detrital. Furthermore, there are partly modified feldspar grains of size 50 – 60  $\mu\text{m}$  and iron compounds from 20 – 40 to 60  $\mu\text{m}$ . The pores are mainly of an irregular extended shape and size 80 – 100  $\mu\text{m}$ , but have more rounded edges than the above clay samples. The structural specific of the clay fired at 1050°C is the emergence of numerous glass areas. The glass-rich areas have a darker color, and their sizes are 20 – 30 and 100  $\mu\text{m}$ .

Thus, the clay fired at 950°C has the highest amount of quartz. Furthermore, this clay has impurities in the form of feldspar and iron compounds. An increase in firing temperature contributes to increasing the quantity of the vitreous phase and decreasing the quantity of residual quartz. The clay fired at 1050°C exhibits the vitrification of the mixture, which may intensify the deformation capacity of the mixture.

The performed studies lead to the following conclusions. Clay from the Semikarakorskoe deposit is low-melting polymineral kaolinite-hydromica clay, poorly sintering, highly drying-sensitive, and of low plasticity. Its impurities include

organic inclusions, calcite, feldspar, and quartz. This clay has a low fire shrinkage and a high porosity. Raising the firing temperature decreases the content of residual quartz and the pore size but has an imperceptible effect on decreasing water absorption.

According to its technical characteristics, clay from the Semikarakorskoe deposit can be used in construction ceramics and in producing majolica. However, it should be taken into account that using this clay in ceramic mixtures, it is advisable to introduce plastic clays, low-melting fluxes, and

other additives needed to produce particular ceramic products.

## REFERENCES

1. E. S. Lukin and N. T. Andrianov, *Technical Analysis and Control of Ceramic Production* [in Russian], Stroiizdat, Moscow (1986).
2. V. P. Ivanova, B. K. Nasotov, and T. N. Krasovina, *Thermal Analysis of Minerals and Rocks* [in Russian], Nedra, Moscow (1974).
3. I. Ya. Yurchak, A. I. Avgustinik, A. S. Zaporozhets, et al., *Analysis and Control Methods in Production of Porcelain and Faience* [in Russian], Legkaya Industria, Moscow (1971).